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In Cooperation with the University of Wisconsin

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Summary

Four Philippine hardwood chip mixtures with average densities of 15, 25, 35, and 45 pounds per cubic foot were pulped by both the neutral sulfite semichemical (NSSC) and kraft processes. The kraft pulps were easily bleached to 90+ percent brightness using CEDED. The highest NSSC pulp handsheet properties were obtained using the lowest average density wood mixture, and all properties decreased as the average wood mixture density increased. Maximum strength kraft pulps were obtained from the wood mixture having an average density of 35 pounds per cubic foot.

Experimental

Makeup of Chip Mixtures

Four chip mixtures, each containing equal amounts of three different Philippine hardwoods of similar density, were made to approximate average mixture densities of 15, 25, 35, and 45 pounds per cubic foot.

1/ Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

NSSC Pulping

NSSC pulps were made from each of the four mixtures using the following conditions:

(1) 16.0 percent sodium sulfite.

(2) 4.0 percent sodium carbonate.

(3) 3.5-to-1 water-to-wood ratio.

(4) 15-minute presteaming at 15 pounds per square inch gage.

(5) 120-minute rise from 80° to 175° C.

(6) 60-minute cooking at 175° C.

These pulps were refined to about 350 milliliters (Canadian Standard freeness) in a 12-inch-diameter, single-rotating disk mill and made into handsheets having a basis weight of 26 pounds per 1,000 square feet. The handsheets were evaluated to determine the possible use of these pulps for the production of corrugating medium.

Kraft Pulping and CEDED Bleaching

Kraft pulps were also made from each of the four mixtures using the following conditions:

(1) 16.0 percent active alkali.

(2) 25 percent sulfidity.

(3) 4-to-1 water-to-wood ratio.

(4) 170° C. cooking temperature.

The time to raise the temperature from 80° to 170° C. ranged from 50 minutes for the lowest density mixture to 80 minutes for the highest density mixture. The time at 170° C. was adjusted to obtain a Kappa number of about 25. Each of the pulps was bleached to 90+ percent

brightness using CEDED. Strength development of the pulps was in a Valley beater, and handsheets were made and evaluated according to standard TAPPI methods.

Results

Properties of Individual Species and Mixtures

The composition of the different density mixtures of Philippine hardwoods is given in table 1. The average specific gravities of the four mixtures were 0.241, 0.392, 0.562, and 0.721. These specific gravity values calculate to densities of 15.0, 24.5, 35.1, and 45.0 pounds per cubic foot. The average fiber length of the four mixtures was about the same for all at 1.5 millimeters. However, there was a wide range in the Runkel ratios of the individual species, with a minimum value of 0.17 and a maximum of 6.38. The average Runkel ratios of the four respective mixtures were 0.32, 0.43, 0.86, and 3.45.

NSSC Pulping and Handsheet Properties

Analyses of the spent liquors and pulp yields are given in table 2. Under the same conditions, there were some differences in response to pulping. The lowest density mixture consumed the most chemical and gave the lowest yield pulp at 71.9 percent. The remaining three mixtures consumed less chemical and consequently were higher in yield. Respective yields of the 25-, 35-, and 45-pound-per-cubic-foot mixtures were 78.1, 79.5, and 75.6 percent.

The handsheet properties of the NSSC pulps are given in table 3. Significant trends are evident as the average density of the mixtures increases; for example:

(1) The bulk of the handsheets increases as shown by an increase in thickness and a decrease in density.

(2) Both burst and tear decrease.

(3) Both ring crush and Concora decrease.

These results indicate that at these yields the lower density wood mixtures are far superior to the higher density wood mixtures in their potential for producing corrugating mediums with acceptable properties. Unfortunately, the properties of the handsheets measured and shown in table 3 do not always relate to the runnability of corresponding mediums through the corrugator. As was found in another study, prediction of runnability of corrugating mediums made from mixed tropical hardwoods is much less positive than for mediums made from Temperate Zone hardwoods. Further work is being done in that study to enable better prediction of runnability prior to actually running mediums through the corrugator.

Kraft Pulping and CEDED Bleaching

Analyses of the black liquors, pulp yields, and Kappa numbers are given in table 4. All four of the mixtures pulped easily, and no identifiable trends were evident as the average density of the mixtures increased. The easiest pulping mixture was the one having an average specific gravity of 0.562, which required only 60 minutes at 170° C., while the other mixtures required 90 minutes at 170° C. to obtain the same Kappa number. The two highest density mixtures also gave more screenings than the lower density mixtures.

The conditions and results of CEDED bleaching of the four kraft pulps are given in table 5. All four pulps responded normally to bleaching, and again no identifiable trends were evident as the average density of the mixtures increased.

Properties of Unbleached and Bleached Kraft Pulps

Kraft pulps appear to be far less sensitive than NSSC pulps to the change in average density of the wood mixture. However, two properties that did increase with increasing average wood density were unbeaten pulp freeness and bulk of the handsheets. Besides having the lowest unbeaten freeness, the pulp made from the lowest average density mixture also developed its strength in much less time than the other pulps. Pulp strength appears to reach a maximum from the mixture having an average specific gravity of 0.562. Coincidentally, the average Runkel ratio of this mixture was 0.86, or nearly unity where maximum pulp strength was found in other studies. The pulp made from the highest density mixture had the lowest bursting and tensile strengths, while the tearing resistance of this pulp was almost as good as that of the strongest pulp. The strength properties of all of the pulps increased upon bleaching, and the general relationships with each other were about the same as those found with the unbleached pulps.

Conclusions

(1) Handsheet properties of NSSC pulps indicate that lower density wood mixtures are far superior to the higher density wood mixtures in their potential for producing corrugating mediums with acceptable properties.

(2) Maximum strength kraft pulps are obtained from wood mixtures having an average density of about 35 pounds per cubic foot. Increasing or decreasing the average wood mixture density lowers strength.

(3) Kraft pulps from all of the mixtures can be easily bleached to 90+ percent brightness with CEDED with no loss in strength.

Table 1.--Composition of different specific gravity mixtures of Philippine hardwoods

Species in mixtures[1]		Specific gravity[2]	Fiber length[3]	Runkel ratio[3,4]
Common name	Botanical name			
			Mm	
Tangisang-bayauak	Ficus variegata	0.236	1.3	0.17
Binuang	Octomeles sumatrana	.242	1.6	.24
Kapok	Ceiba pentandra	.244	2.0	.56
Average		.241	1.6	.32
Matang-arau	Melicope triphylla	.381	1.4	.39
Malasantol	Sandoricum vidalii	.394	1.4	.34
White lauan	Pentacme contorta	.401	1.6	.57
Average		.392	1.5	.43
Lomarau	Switonia foxworthyi	.559	1.4	.68
Malabetis	Madhuca oblongifolia	.560	1.6	.83
Dangkalan	Calophyllum obliquinervium	.568	1.4	1.06
Average		.562	1.5	.86
Yakal	Shorea astylosa	.718	1.6	6.38
Kamagong	Diospyros philippenensis	.720	1.1	1.60
Katong-matsin	Chisocheton pentandrus	.725	1.5	2.37
Average		.721	1.4	3.45

1/ Equal amounts of each of the 3 species (dry-weight basis).
2/ Dry weight, green volume basis.
3/ Based on measurements made on macerated wood.
4/ Double cell wall thickness divided by lumen diameter. Runkel, R.O.H., Das Papier 3: 476(1949).

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Table 2.--NSSC pulping[1/] of different specific gravity mixtures of Philippine hardwoods

Average specific gravity	Digestion No.	Spent liquor		Yield[2/]
		Na_2SO_3	pH	
		G/1		Pct
0.241	2525Y	15.4	9.2	71.9
.392	2526Y	25.3	8.5	78.1
.562	2527Y	21.5	9.0	79.5
.721	2528Y	25.7	9.1	75.6

1/ Constant conditions used were 16.0 pct Na_2SO_3, 4 pct Na_2CO_3, 3.5-to-1 water-to-wood ratio, 15-min presteaming at 15 lb/in^{2}g, 120-min rise from 80° to 175° C., and 60 min at 175° C.

2/ Moisture-free wood basis.

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Table 3.--Handsheet properties of NSSC pulps made from different specific gravity mixtures of Philippine hardwoods

Average specific gravity	Average Runkel ratio	Digestion No.	Pulp yield	Freeness (Canadian Standard)	Basis weight	Thick-ness	Burst factor	Tear factor	Apparent density	Ring crush	Concora
			Pct	Ml	Lb/1,000 ft^2	Mils			G/cm^3	Lb	Lb
0.241	0.32	2525Y	71.9	335	26.6	9.2	32.7	71.4	0.50	67.6	72.0
.392	.43	2526Y	78.1	370	26.5	10.9	21.9	64.1	.42	60.0	60.6
.562	.86	2527Y	79.5	345	26.3	10.8	17.2	59.6	.41	53.2	53.8
.721	3.45	2528Y	75.6	305	26.9	12.2	12.5	51.6	.38	42.2	45.2

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Table 4.--Kraft Pulping[1/] of different specific gravity mixtures of Philippine hardwoods

Average specific gravity	Digestion No.	Time to 170° C.	Time at 170° C.	Black liquor		Yield[2/]		Kappa number
				NaOH (Na_2O)	Na_2S (Na_2O)	Total	Screenings (10-cut)	
		Min	Min	G/l	G/l	Pct	Pct	
0.241	6009X	50	90	4.1	6.5	44.3	0.7	27.5
.392	6010X	60	90	3.1	7.3	48.4	.6	23.0
.562	6054X	70	60	5.7	7.8	49.1	1.7	22.6
.721	6016X	80	90	7.3	6.5	47.6	1.8	25.7

1/ Constant conditions used were 16.0 pct active alkali, 25 pct sulfidity, and 4-to-1 water-to-wood ratio.

2/ Moisture-free wood basis.

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Table 5.--CEDED bleaching[1/] of kraft pulps made from different specific gravity mixtures of Philippine hardwoods

Stage No.	Average specific gravity	Kappa number	Bleach No.	Chemical			pH		Brightness		Viscosity	Yield
				Name	Amount applied	Amount consumed	Initial	Final	Initial	After aging[2/]		
					Pct	Pct			Pct	Pct	cP	Pct
1	0.241	27.5	6807	Chlorine	5.80	5.75	3.1	3.0	--	--	--	--
1	.392	23.0	6816	.....do.....	5.40	5.35	2.7	2.6	--	--	--	--
1	.562	22.6	6805	.....do.....	5.40	4.75	3.0	2.8	--	--	--	--
1	.721	25.7	6806	.....do.....	6.00	5.76	2.9	2.8	--	--	--	--
2	--	--	6807	Sodium hydroxide	2.00	--	11.6	11.3	--	--	--	--
2	--	--	6816	.....do.....	2.00	--	11.8	11.6	--	--	--	--
2	--	--	6805	.....do.....	2.00	--	11.8	11.6	--	--	--	--
2	--	--	6806	.....do.....	2.00	--	11.6	11.4	--	--	--	--
3	--	--	6807	Chlorine dioxide	.76	.76	--	3.8	--	--	--	--
3	--	--	6816	.....do.....	.76	.76	--	3.9	--	--	--	--
3	--	--	6805	.....do.....	.76	.76	--	3.8	--	--	--	--
3	--	--	6806	.....do.....	.76	.76	--	4.0	--	--	--	--
4	--	--	6807	Sodium hydroxide	1.00	--	11.5	11.3	--	--	--	--
4	--	--	6816	.....do.....	1.00	--	11.7	11.6	--	--	--	--
4	--	--	6805	.....do.....	1.00	--	11.7	11.4	--	--	--	--
4	--	--	6806	.....do.....	1.00	--	11.6	11.4	--	--	--	--
5	--	--	6807	Chlorine dioxide	.38	.38	--	6.1	91.8	88.9	16.9	95.0
5	--	--	6816	.....do.....	.38	.38	--	6.4	90.7	86.6	11.7	97.6
5	--	--	6805	.....do.....	.38	.38	--	6.2	92.5	90.2	15.4	96.8
5	--	--	6806	.....do.....	.38	.38	--	6.1	90.4	87.1	14.3	94.0

1/ Constant conditions used for temperature, consistence, and time were as follows: Stage 1--25° C., 2 pct, and 60 min; stage 2--70° C., 10 pct, and 60 min; stages 3 and 5--70° C., 10 pct, and 240 min; stage 4--50° C., 10 pct, and 60 min.

2/ For 1 hr in an oven at 105° C.

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Table 6.--Properties of unbleached and bleached kraft pulps made from different specific gravity mixtures of Philippine hardwoods

Average specific gravity	Average Runkel ratio	Digestion No.	Pulp type	Pulp properties				Handsheet properties					
				Kappa number	Average fiber length	Coarseness	Fibers per gram	Freeness (Canadian Standard)	Beating time	Burst factor	Tear factor	Breaking length	Apparent density
					Mm	Mg/100 m	$\times 10^{-5}$	Ml	Min			Km	G/cm^3
0.241	0.32	6009X	Unbleached	27.5	1.01	11.7	87.0	555	0	41.7	99.0	7.3	0.64
								550	1	42.0	97.0	7.4	.65
								350	13	75.0	72.0	10.9	.71
			Bleached	--	--	--	--	565	0	41.0	102.5	6.9	.70
								550	6	56.0	93.5	8.6	.75
								350	18	75.0	74.0	10.7	.81
.392	.43	6010X	Unbleached	21.0	1.14	13.4	73.7	650	0	22.4	98.8	5.3	.57
								550	20	52.0	106.5	8.6	.67
								350	68	74.0	80.5	11.0	.80
			Bleached	--	--	--	--	630	0	29.6	111.5	6.5	.66
								550	14	57.0	107.0	9.9	.73
								350	44	82.0	97.0	12.9	.79
.562	.86	6054X	Unbleached	22.6	.96	10.3	100.3	680	0	21.4	138.6	5.2	.52
								550	30	56.0	135.0	9.4	.64
								350	58	77.5	120.0	11.7	.71
			Bleached	--	--	--	--	685	0	20.3	107.5	4.8	.55
								550	22	60.5	124.0	9.5	.67
								350	41	79.5	119.5	11.2	.72
.721	3.45	6016X	Unbleached	25.7	.97	11.8	86.4	690	0	13.5	95.4	3.9	.46
								550	18	35.0	117.5	6.4	.54
								350	38	55.5	133.5	8.7	.61
			Bleached	--	--	--	--	565	0	15.3	87.3	3.8	.47
								550	34	42.0	133.0	7.2	.57
								350	65	60.0	132.0	9.3	.62

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